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ARAI Yoichi

University of California

HOSHI Takeo

RIETI



Research Institute of Economy, Trade & Industry, IAA

The Research Institute of Economy, Trade and Industry

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Monetary Policy in the Great Recession*

Yoichi Arai**

and

Takeo Hoshi***

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ABSTRACT

This paper reviews the monetary policy in Japan during the “great recession.” The paper focuses especially on the conduct of monetary policy when the ZIRP (zero interest rate policy) was in place. The nominal call rate was virtually zero, but we find the monetary policy was not that expansionary in some other dimensions. We examine the long-run relation between the real M2+CD and the real GDP, taking into account of a possible shift in the co-integrating relation. The analysis shows there was a long-run relation between the two variables throughout the sample period (1980-2003), although the slope of the co-integrating vector changed around late 1995. Thus, monetary policy did not lose its long-run effectiveness in this sense. The co-integrating relation between M2+CD and the monetary base also seems to have changed around late 1998. In both before and after the regime shift, the long-run relation between M2+CD and the monetary base is positive, suggesting an increase in the monetary base leads to an increase in M2+CD in the long run. Overtime, the relation has become weaker, but the relation continues to be positive, suggesting an increase in the monetary base still leads to an increase in M2+CD.

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** Department of Economics at University of California, San Diego

*** Graduate School of International Relations and Pacific Studies at University of California, San Diego, RIETI, and NBER

1. Introduction

Since the early 1990s, Japan has been experiencing perhaps the longest stagnation and recession that a developed economy has ever seen in the post-war period. From the first quarter of 1990 to the first quarter of 2003, the real GDP grew only at 1.43% per year. Over the 13 years, the price level measured by the GDP deflator declined by 3.2%. The deflation rate over the last five years has been especially serious at 8.6%, about 1.8% per year. As the economy stopped growing, the unemployment rate more than doubled from 2.2% (January 1990) to 5.4% (March 2003). The economy has shown some signs of recovery since the mid-2003. In the fourth quarter of 2003, the real GDP grew by 1.7% (or 7.0% at annual rate) and the unemployment rate declined to 4.9% (December 2003). It is, however, too early to tell if the Japanese economy is finally coming out of the more than decade long recession. The GDP deflator still continued to fell by 2.6% from the previous year.

This paper reviews the monetary policy during this “great recession” in Japan.¹ The paper focuses especially on the conduct of monetary policy after February 1999, when the Bank of Japan (BOJ) introduced the ZIRP (zero interest rate policy). Governor Hayami characterized this policy “super super expansionary” during the press conference when the BOJ lifted the ZIRP on August 11, 2000.² The paper asks the following questions. Has the monetary policy been really super expansionary? If so, why did it fail (at least so far) to stop the deflation and recession? If the policy is found not that expansionary, what more (than the BOJ has already done) can the BOJ do?

The paper starts with a brief overview of the Japanese monetary policy since the early 1990s in Section 2. Section 3 examines whether the monetary policy has been super expansionary by looking at several measures of the monetary policy stance. Looking at nominal interest rates, we find the monetary policy in the late 1990s was indeed expansionary. Other measures such as growth rates of monetary aggregates suggest, however, the monetary policy in the late 1990s was not super expansionary compared with some past episodes of monetary expansion. Section 4 discusses “quantitative easing” that the BOJ seems to have started in 2001 and examines the effectiveness of such monetary policy both theoretically and empirically. Section 5 concludes.

2. Chronology

On July 1, 1991, the Bank of Japan decided to cut the official discount rate by 50 basis points (from 6.00% to 5.50%). The asset price bubbles had been popped, and the economy started to show some signs of weakness. Over the next four years, the Bank of Japan gradually cut the discount rate as the economy continued to stagnate. The rate was

¹ Kuttner and Posen (2001) is the first paper to call the recent Japanese macroeconomic experience “great recession.”

² A transcript of the press conference is found at <http://www.boj.or.jp/press/kisha064.htm>. The BOJ reinstated the ZIRP in March 2001, seven months after the original ZIRP was lifted.

cut by 50 basis points on November 14, 1991, by another 50 basis points on December 30, 1991, by 75 basis points on April 1, 1992, by 50 basis points on July 27, 1992, by 75 basis points on February 4, 1993, by another 75 basis points on September 21, 1993, yet another 75 basis points on April 14, 1995, and finally by 50 basis points on September 8, 1995. After all these gradual rate cuts, the official discount rate after September 1995 stood at 0.50%.

In 1996, the real GDP grew by 5.1%, helped by the expansionary fiscal policy as well.³ The Bank of Japan did not cut the discount rate. Starting in the second quarter of 1997, however, the economy slowed down again. Phasing out of the 1995 income tax cut, the consumption tax rate hike (from 3% to 5%), and raised co-payments for the national health insurance system, all introduced in April 1997, contributed to the slowdown of the economy. At the same time, the non-performing loan problem in the banking sector, which was serious at least from 1993, reached a peak in late 1997. Hokkaido Takushoku Bank, one of the largest banks in Japan, and Yamaichi Securities, one of the big four security houses, both failed in November 1997. The financial system got into a crisis and the economy went back into a recession. The BOJ provided emergency loans to the failed entities and pumped into liquidity in the call market (inter-bank market) where the supply almost dried up. The BOJ also made loans to the Deposit Insurance Corporation (DIC) later, which started to play more important roles in providing assistance to failed financial institutions. The stance of monetary policy, however, did not change substantially during the crisis of 1997-1998. The BOJ kept the official discount rate at 0.50% and targeted the overnight call rate to be slightly below the discount rate.

In 1998, the legal foundation of the BOJ went through a major change. The Bank of Japan Act of 1942, which made the BOJ formally dependent on the government, was repealed, and the BOJ gained formal independence under the New Bank Japan Act of 1998. The new legislation passed the Diet in June 1997 and became effective April 1, 1998. Table 1 shows the major monetary policy changes from 1998, when the BOJ gained independence, to date.

As the new BOJ observed the economic condition of Japan to deteriorate, the monetary policy was further relaxed on September 9, 1998. The target rate for uncollateralized overnight calls was lowered to 0.25%. The BOJ also stated “regardless of the above guideline for the call rate, the Bank of Japan will provide more ample funds, if judged necessary, to maintain the stability of the financial markets.” In the statement released immediately after the monetary policy meeting, the BOJ cited the possibility of deflation as an important factor that influenced their decision. The BOJ stated “the monetary policy objective of the Bank of Japan is to pursue price stability, avoiding both inflation and deflation.”⁴ But the BOJ also expressed the view that the objective cannot be achieved solely by monetary policy. At the end of the statement, the BOJ added:

³ For the role of fiscal policy in the recovery of 1996 and in the 1990s Japan in general, see Posen (1998), and Kuttner and Posen (2001).

⁴ “Change of the Guideline for Money Market Operations,” September 9, 1998 (available as <http://www.boj.or.jp/en/seisaku/98/pb/k980909c.htm>).

At present, recovery of business conditions and revitalization of the financial system are the imminent issues in the Japanese economy. The Bank of Japan strongly hopes that the decision to make money market operations more accommodative will facilitate the resolution of these issues and that all parties concerned will make their utmost efforts in surmounting the economic difficulties they face. (“Change of the Guideline for Money Market Operations,” September 9, 1998)

Thus, the statement clearly shows the BOJ’s view that the recession is a structural problem and Japan needs structural reform to recover from the recession. This view has continued to influence the monetary policy formulation at the BOJ.

The further monetary accommodation did not bring about the visible recovery of the economy in early 1999. On February 12, 1999, the BOJ decided to lower the target rate further to effectively zero. This marked the start of the ZIRP. The BOJ started to “encourage the uncollateralized overnight call rate to move as low as possible.” In the press release, the BOJ re-iterated their view that the recession is a structural problem.

In order to bring Japanese economy back to a solid recovery path, it is important not only to provide support from monetary and fiscal sides but also to steadily promote financial system revitalization and structural reforms. (“Change of the Guideline for Money Market Operations,” February 12, 1999)

The ZIRP lasted for a year and a half. Contrary to the BOJ’s hope, the structural reforms did not progress quickly, and the financial system continued to suffer from the non-performing loan problems. On August 11, 2000, the BOJ lifted the ZIRP, claiming “Japan’s economy has reached the stage where deflationary concern has been dispelled,” although many observers (including the government) pointed out that the deflation had not stopped.

As soon as the BOJ lifted the ZIRP, the economic condition started to deteriorate again. The index of industrial production (IP) started to fall after it peaked at 108.3 (1995 average = 100) in August 2000. By January 2001, the IP declined by 5% to 102.9. But, the BOJ was reluctant to go back to the ZIRP. On February 9, the BOJ cut the official discount rate, which had been constant at 0.50% since September 1995, to 0.35%, and created a ‘Lombard-type’ lending facility, which stands ready to provide funds to financial institutions at the official discount rate. At this time, the BOJ did not change the target rate for the overnight call rate.

In the next policy meeting (February 28, 2001), the BOJ moved back closer to the ZIRP. The target rate for the uncollateralized overnight call rate was reduced to 0.15%. At the same time, the official discount rate was reduced to 0.25%.

Finally in the next meeting (March 19, 2001), the BOJ effectively reinstated the ZIRP. The BOJ decided to target the outstanding balance of current accounts of banks held at the Bank of Japan, abandoning the call rate targeting. The BOJ announced the target balance of around ¥5 trillion, which was believed to be enough to drive down the

overnight call rate effectively to zero. At the same time, the BOJ announced that this procedure would continue “until the consumer price index (excluding perishables, on a nationwide statistics) registers stably a zero percent or an increase year on year.”

The stated commitment to ZIRP until the annual CPI inflation rate registers 0% or higher is noteworthy. In the theoretical models developed by Jung, Teranishi and Watanabe (2001) and Eggertsson and Woodford (2003), which will be discussed later in this paper, such a commitment can constitute an important part of the optimal monetary policy when zero interest rate constraint is binding. The BOJ, however, did not stress the importance of this commitment very much.

The policy also appeared to be an inflation targeting, which was advocated by many economists, although the inflation target of 0% may have been too low, given the well-known upward bias of the consumer price index.⁵ When asked if the new policy constitutes the introduction of inflation targeting, however, the BOJ quickly denied it, negating a potentially important announcement effect.⁶

As the recession continued in 2001, the BOJ raised the target balance of current accounts. On August 14, 2001, the target balance was raised to ¥6 trillion. The BOJ also decided to increase the amount of outright purchase of long-term government bonds to ¥600 trillion per month (from then current level of ¥400 trillion). On September 18, 2001, the target was raised to *over* ¥6 trillion. On December 19, 2001, the target balance was set to ¥10 trillion to ¥15 trillion. At the same time, the amount of outright purchase of long-term government bonds increased to ¥800 billion per month.

On February 28, 2002, the target balance was once again raised to *over* ¥15 trillion, and the amount of the government bond purchase increased to ¥1 trillion per month. This decision was made one day after the Japanese government announced its “anti-deflationary measures,” which encouraged the BOJ to take “bold monetary policy.” In the press release, the BOJ once again stressed the importance of structural reforms in stopping the deflation, and showed the willingness to support as long as the government is serious about the structural reforms.

⁵ For example, Shiratsuka (1999) estimates the upward bias of the Japanese CPI to be about 0.9% per year.

⁶ Actually, the BOJ denied it even before it is asked. Here is a quote from a note that the BOJ released when they announced the policy change on March 19, 2001.

Q7: Does it mean that the Bank has adopted inflation targeting?

A7: Inflation targeting is usually defined as a scheme under which 1) a desirable inflation rate from a long-term perspective is set as a target and 2) a central bank adjusts monetary policy in a forward-looking manner when an actual inflation rate is expected to deviate from the target. The Bank's policy on inflation targeting is that we have to further examine its desirability and feasibility because it is difficult to numerically define a desirable inflation rate from a long-term perspective in the current situation in Japan. This time, the Bank committed itself that this unorthodox policy will be continued until the actual CPI registers a zero percent or an increase year on year. Although it is not inflation targeting, it shows the Bank's determination to prevent a continuous price decline and to form a basis for a sustainable growth. (“Q&A: New Procedures for Money Market Operations,” March 19, 2001)

To realize the full permeation of the effects of strong monetary easing, it is essential to strengthen a financial system and ensure its stability by making a swift move to resolve the non-performing loan problem. It is also vital to make progress in structural reform on the economic and industrial fronts through tax reform, streamlining of public financial institutions, and deregulation. The Bank strongly hopes that both the Government and the private sector, in particular financial institutions, will take more determined and effective steps in this regard. (“On Today’s Decision at the Monetary Policy Meeting,” February 28, 2002)

Resolution of the non-performing loan problem, however, did not move as swiftly as the BOJ hoped. The FSA carried out the “special inspection” of major banks, focusing on the loans to their largest borrowers. The result of the inspection, which was published in April of 2002, concluded that all the major banks were well capitalized and they do not need recapitalization.

The reluctance of the FSA to admit the seriousness of the non-performing loan problem and to consider the use of public funds to recapitalize the banks eventually prompted the Prime Minister Koizumi to change the head of the FSA on October 1. With the new FSA Minister Heizo Takenaka, who was also Minister of State for Economic and Fiscal Policy, the government reformulated the anti-deflationary package and published “Comprehensive Measures to Accelerate Reforms” on October 30.⁷

Earlier on the same day (October 30, 2002), the Bank of Japan announced a change in the monetary policy. The targeted level of current accounts held at the BOJ was increased to around ¥15 trillion to ¥20 trillion. The amount of outright purchase of long-term government bonds was raised to ¥1.2 trillion per month. The BOJ re-iterated the importance of structural reform in the financial system to revive the Japanese economy.

In order to ensure the abundant liquidity provision by the Bank leading to the revitalization of the economy, improvement in credit allocation function of capital markets is important in addition to the strengthening of the financial intermediary function of banks. In this regard, the Bank will closely monitor the impact of expected government measures to accelerate the resolution of the NPL problem on corporate financing and explore possible measures to secure the smooth working of corporate financing. (“Change in the Guideline for Money Market Operations,” October 30, 2002)

The BOJ introduced the plan of buying stocks held by banks in October. A rough plan was announced on September 18 and the details were disclosed on October 11. According to the plan, the BOJ would buy up to ¥2 trillion of stocks from banks in two years. Although the BOJ could have placed this measure within the framework of quantitative easing as another way to provide liquidity to the economy, it did not. The BOJ stressed the goal was to improve the health of the banking system by reducing the

⁷ The policy announcement is available at the web site of the Prime Minister’s Office (www.kantei.go.jp/foreign/policy/2002/021030sougou_e.html).

banks' exposure to the stock market risk. The amount of ¥2 trillion in 2 years was also probably too small to make a difference as a part of quantitative easing.

On March 19, 2003, Masaru Hayami completed the five year term as the BOJ Governor and stepped down. On the following day, Toshihiko Fukui became the new governor of the BOJ. On March 25, the new governor called for an *ad hoc* Monetary Policy Meeting. The BOJ did not make any changes to the current monetary policy stance, but announced that they would increase the amount of stock purchase from banks to ¥3 trillion. The first major change of the monetary policy under Governor Fukui was decided on April 30, 2003. The BOJ raised the target range of current accounts held at the BOJ to ¥22 to ¥27 trillion.⁸ The target for the outright purchase of long-term government bonds was not changed.

Thus, the arrival of Governor Fukui initially did not seem to create any explicit break in the BOJ's policy. Overtime, however, the BOJ under Governor Fukui started to appear different from the one under Governor Hayami in its more explicitly expansionary stance. On May 20, 2003, less than a month since the last increase in the target level, the BOJ level raised the target level of current accounts to ¥27-¥30 trillion. On October 10, 2003, the target range was further raised to ¥27-¥32 trillion. More importantly, the bank reiterated its commitment to maintain the quantitative easing until the CPI inflation rate registers 0% or higher. As we discussed above, committing to the future monetary policy becomes important when the current monetary policy alone cannot stimulate the economy. When the BOJ restored the ZIRP in March 2001, it stated the commitment to continue the quantitative easing until the CPI inflation rate becomes zero or higher. In October, 2004, the BOJ further clarified the statement. To terminate the quantitative easing, the BOJ declared, it is necessary (i) for the core CPI inflation rate of 0% or above to continue for a few months at least, and (ii) for the BOJ to be convinced that the core CPI inflation will not be expected to be 0% or below in the near future.

On January 20, 2004, the BOJ surprised many observers by raising the target range for the outstanding balance of current accounts to ¥30-¥35 trillion. Observing the recent recovery of the Japanese economy, only few expected the BOJ to expand the monetary policy further. Pointing out to the continuing deflation, and to reconfirm the commitment to the quantitative easing, however, the BOJ raised the target range. It seems clear that Governor Fukui has been more serious about expanding monetary policy than his predecessor, and the BOJ has a firm commitment to continue the quantitative easing until it is certain that the deflation has ended.

3. Has the Monetary Policy Been Super Expansionary?

The BOJ continued to cut the interest rate and tried to boost the economy for the most part of the 1990s. By February 1999, the target overnight call rate reached

⁸ The target range had been already raised to ¥17 to ¥22 trillion as of April 1, because the postal saving system was semi-privatized and newly created Japan Post started to hold a deposit account at the Bank of Japan.

effectively zero, which is indeed “unprecedentedly low during the history of central banking at home and abroad.”⁹ The ZIRP was suspended in August 2000, but essentially restored in March 2001. Since then, the BOJ has been targeting the quantity of current accounts held at the Bank instead of any interest rates. This section examines how expansionary those monetary policy measures have really been. We will find the monetary policy of the BOJ has not been as expansionary as it was claimed to be until very recently.

Figure 1, which shows the overnight call rate from January 1974 to December 2003, is consistent with the BOJ’s claim that the monetary policy since the late 1990s has been super expansionary.¹⁰ The call rate fell substantially in the 1990s and eventually reached the level that cannot go lower.

When we look at the ex-post real call rate, subtracting the CPI inflation rate, the picture becomes less clear (Figure 2).¹¹ The real rate also came down during the 1990s, but the real rate stayed often substantially above zero because of deflation. As a result, the real call rate in the late 1990s and the early 2000s did not go as low as it did in the inflationary 1970s.

As nominal interest rates reached virtually zero, many commentators in and outside Japan, academic and non-academic, started to discuss the possibility of effective monetary expansion when the zero interest rate constraint is binding. Many of them ended up suggesting aggressive expansion of monetary aggregates. If the central bank prints and injects more money into the economy, the nominal aggregate demand eventually increases. This point can be understood most simply by considering the quantity equation, $MV=PY$, where M is money, P is the price level, Y is real aggregate demand, and V is the income velocity of money. When M increases, unless V declines at the same speed (or faster), PY must increase in the limit. Even if the increase in the nominal aggregate demand does not immediately show up as an increase in output, the increase in the monetary aggregates should raise the price level and create inflation, thereby allowing the real interest rate to fall below zero, which would help the economy. Bernanke (2000) explains this point very clearly.

⁹ Bank of Japan “New Procedures for Money Market Operations and Monetary Easing,” March 19, 2001 (available as <http://www.boj.or.jp/en/seisaku/01/pb/k010319a.htm>).

¹⁰ The figure shows the monthly averages for collateralized overnight rates. The uncollateralized overnight rate series, used as the target rate by the BOJ, is available only after July 1985. The difference between the two rates is miniscule especially in the 1990s. The data on the call rate and other financial variables used in this section were obtained from the web site of Bank of Japan (www.boj.or.jp/en/stat/dlong_f.htm) unless noted otherwise.

¹¹ We use the general CPI index published by the Statistics Bureau of Ministry of Public Management, Home Affairs, Posts and Telecommunications. The data are available at their web site (www.stat.go.jp/english/data/cpi/index.htm). We adjust the CPI to remove the effects of the introduction of the consumption tax in 1989 and its rate hike in 1997. To do this, we first estimate an ARMA model of the CPI in level with two dummy variables: one that takes 1 only before the tax change in 1989 and the other that takes 1 only before the tax change in 1997. Using the coefficient estimates on these dummies, we adjust the values of CPI before the tax changes so that they are comparable to the series after the changes.

The monetary authorities can issue as much money as they like. Hence, if the price level were truly independent of money issuance, then the monetary authorities could use the money they create to acquire indefinite quantities of goods and assets. This is manifestly impossible in equilibrium. Therefore money issuance must ultimately raise the price level, even if nominal interest rates are bounded at zero. (Bernanke 2000, p.158)

During the Japanese recession, the BOJ has not explicitly targeted growth of monetary aggregates. Provision of “ample funds” to the financial market under the “unprecedented accommodative monetary policy,” however, may have led to a substantial quantitative easing as a result. This may be more likely for the period after March 2001, when the BOJ started explicitly targeting the balance of current accounts held at BOJ, which is an important component of the monetary base.

To see if such quantitative easing indeed happened in Japan, Figures 3 and 4 plot the year on year growth rates of monetary aggregates. The growth rate of M2+CD (Figure 3) increased from 1993 to 1995, but has been rather stable since then at around 3% per annum.¹² If we compare the monetary growth in the recent years to that in the 1970s and the 1980s, we find the recent growth rate has been rather low.

Figure 4 shows the growth rates of adjusted monetary base (monetary base adjusted for the changes in the reserve requirement). Again, the monetary growth rates in the late 1990s were slightly higher than those in the early 1990s, but were rather low compared with the growth rates in the 1970s and the 1980s. The only exceptions are the spike in the growth rate in December 1999 and January 2000, when the BOJ increased liquidity to deal with potential Y2K related problems, and the increased monetary growth from September 2001 on. Even the growth rates during these two episodes are roughly comparable to the growth observed in the mid 1970s.

Thus, judging from the growth rate of monetary aggregates, we cannot observe clear evidence for “super expansionary” monetary policy. The growth rate of M2+CD has been rather low throughout the 1990s and early 2000s. Even the monetary base, which should be easier to control, did not show dramatically high growth rates before the September 2001. Thus, it seems reasonable to conclude that the quantitative easing has not been tried in Japan, at least until the late 2001.

One may argue that nominal growth rates of monetary aggregates are not good measures of monetary policy stance. For example, a 2% monetary growth may represent

¹² The coverage of M2+CD published by the Bank of Japan has changed from April 1998 to include the deposits at branches of foreign banks and the Central Shinkin Bank. Thus, the M2+CD series before and after April 1998 are not strictly comparable. We link the two series to get the M2+CD series that we use for the analyses in this paper in the following way. First, we calculate the difference between the two definitions as of April 1998. We can do this because the Bank of Japan continued to publish the M2+CD with the old definition till March 1999. We find the new definition was larger than the old definition by 0.48% in April 1998. We assume the gap between the old definition and the new definition was negligible in January 1975 and grew linearly over time. This allows us to convert the M2+CD series with the old definition to something comparable to that with the new series.

a tight monetary policy when the inflation rate is in double digits, but the same 2% monetary growth may be rather expansionary under deflation. To address this concern, Figures 5 and 6 show the growth rates of real balances, which are defined to be the level of monetary aggregates divided by the CPI. Compared with earlier figures, Figures 5 and 6 make the monetary policy in the high inflation 1970s look less expansionary. The main result, however, does not change. The growth rates of M2+CD in the 1990s and the 2000s were not very high. The growth rates of monetary base were not high, either, until late 2001.

4. Effects of Quantitative Easing

Under what the BOJ calls “unprecedented accommodative monetary policy,” the overnight call rate reached as close to zero as it can get. This may apparently suggest that the monetary policy in Japan has been extremely expansionary. The real rate, however, stayed positive for most of the period, because of deflation. Moreover, the rather low growth of monetary aggregates (M2+CD and adjusted monetary base before the late 2002) suggests that the BOJ did not try substantial quantitative easing, which many economists advocated. In this sense, the monetary policy during the great recession was not super expansionary.

Since around September 2001, the growth rate of monetary base has been high, although the growth of M2+CD has been modest. Has such quantitative easing had expansionary effects on the economy? If the BOJ continues the current policy of quantitative easing, will it eventually stop the deflation and put the Japanese economy on a recovery path? These are the questions we ask in this section.

Theoretical arguments that suggest such quantitative easing must work eventually in some way have been provided by many researchers. For example, Bernanke (2000) forcefully and convincingly argues that monetary policy can be used to increase the aggregate demand even with zero nominal interest rate, as we cited above. He lists four kinds of actions that a central bank could take to stimulate the aggregate demand, all of which are accompanied by some type of “quantitative easing.” Bernanke’s list serves as a useful guide to summarize the theoretical arguments for quantitative easing advanced by many economists.

First, the central bank can continue to set the interest rate at the lowest level (zero) with an explicit inflation target. This is an idea that was initially advanced by Krugman (1998, 2000). If the central bank commits to continue the accommodative interest rate policy until the inflation rate reaches some positive level (e.g., 3-4%), it would raise the people’s inflation expectations and hence reduce the real interest rate below zero. To change the inflation expectations, the central bank may need to take an action that will indeed lead to positive inflation eventually, such as printing more money.

It is important to note that quantitative easing in this case works through changing people's expectations.¹³ Eggertsson and Woodford (2003) shows that simply increasing the quantity of money when the short-term interest rate is already at zero would not have any impacts on the economy unless such an action changes expectations about future interest rate policy or the future government liabilities. If the quantitative easing successfully signals more expansionary policy when the zero interest rate constraint is not binding any more, then it can stimulate the economy today.

Eggertsson and Woodford (2003) also finds that the optimal interest rate policy would continue the zero interest rate for a while even after the economy comes out of the zero interest rate trap, confirming the result obtained by Jung, Teranishi and Watanabe (2001). Eggertsson and Woodford further show that the optimal policy can be implemented as a relatively simple price level targeting (with time-varying target level when the zero interest rate continues). They argue quantitative easing may be useful in communicating the central bank's intent on following the price level targeting when the zero interest rate constraint is binding. The central bank may not be able to hit the target if the interest rate is at zero, but by supplying the amount of money that would be demanded if the price level were at the target level, they may be able to signal that they are serious in keeping the target.

Auerbach and Obstfeld (2003) presents another extension of Krugman (1998) model, where quantitative easing works by changing the expectations regarding the future monetary policy when the zero interest rate constraint is not binding. According to their model, as long as there is non-zero probability that the economy escapes the zero nominal interest rate bound some time in the future, the central bank can change the price level of that period by *permanently* increasing the level of money supply today.

The second policy Bernanke (2000) discusses is depreciation of the home currency. Yen depreciation, for example, would stimulate the aggregate demand by increasing the demand for Japanese exports, by stopping the import-price deflation, and by influencing the future expected inflation. This policy would require large sales of yen and hence increase the monetary growth. Many economists, including Meltzer (2001), McCallum (2000), and Svensson (2000) (just to name a few) advocated quantitative easing to allow yen depreciation.

The third on the list is money financed transfers to households. This amounts to an equivalent of a helicopter drop of new money. Theoretically, it seems obvious that this must raise the price level eventually and hence help the economic recovery. If it did not, the Japanese households would just continue to accumulate the financial assets (new money) without bound, which sounds implausible.

¹³ As Blanchard (2000) pointed out, this is not "exotic." "one can argue that monetary policy works mostly – entirely? – through its effects on expectations. If, when the federal funds rate changed in the United States, financial markets did not expect this change to last for some time, the change would barely affect the term structure of interest rates. It is only because financial markets expect the change in the federal funds rate to last for some time that the term structure is so strongly affected by monetary policy." (Blanchard, 2000, pp.191-192).

Eggertsson and Woodford (2003) argues that money financed fiscal transfers can help also by giving the central bank an incentive to commit to the optimal policy. In their model, the optimal policy involves maintaining zero interest rate and allowing higher inflation rate when the economy comes out of the zero nominal rate trap. Expansion of the government debt and/or central bank liabilities during the zero interest rate periods will give the central bank another incentive to inflate, thereby sticking to the commitment.

Finally, Bernanke (2000) adds non-standard market operations to the list. The central bank buys (instead of short-term government bonds) non-performing loans in the banking sector or long-term government bonds, thereby expanding the monetary base. He argues that this will eventually increase the aggregate demand. Purchase of real assets can serve as another commitment device because it also increases the incentive for the central bank and the government to inflate (Eggertsson and Woodford 2003).

The theoretical arguments show that quantitative easing must eventually raise the nominal aggregate demand through some mechanism even when the short term interest rate is zero. The empirical evidence, however, is limited, partly because the interest rate in major countries did not hit zero until it did in Japan and partly because the BOJ did not really try a substantial quantitative easing until recently.

Hsieh and Shimizutani (2001) is one of the few exceptions. They examine the effects of ¥620 billion consumption vouchers that were distributed to households with children or elderly in April 1999. This can be considered to be a small-scale experiment of helicopter drop of money, which is a form of radical quantitative easing with fiscal transfers. They find the consumption vouchers increased the consumption by 10% (of the amount of vouchers) in the long run in a typical household with children. Data constraint prevented them from estimating the impact of the program on households with elders. Thus, their study suggests that the consumption vouchers experiment increased the aggregate consumption by at least ¥62 billion (about 0.012% of GDP).

Miyao (2000) estimates a VAR (vector autoregressive) model of monetary base, call rate, exchange rate and industrial production, and finds the effect of monetary base expansion on industrial production ceased to exist for the mid-1990s (1993 to 1998). Using data from more recent period, Kimura, Kobayashi, Muranaga, and Ugai (2002) obtains similar results. For quarterly data on inflation rate, output gap, the overnight call rate, and the growth rate of monetary base, they estimated a VAR with time-varying parameters for two sample periods (1971:2-1985:2 and 1985:3-2002:1), and compared the estimated impulse response function at 1985:2 to that at 2002:1. The positive effect of monetary growth on inflation and output existed at 1985:2 but disappeared by 2002:1.

Kuttner and Posen (2001) estimate a VEC (vector error correction) model of M2, real GDP and the GDP deflator, and find a permanent increase in M2 in fact raises the price level. The relation seems to have gotten weaker in the 1990s, but still exists. They fail to find a similar relation between monetary base and the price level, however, mainly because of the lack of observed permanent shocks to monetary base in Japan between

1969 and 2000.¹⁴ They nonetheless find an increase in the monetary base leads to a temporary (2 to 3 years) increase in the price level.

Okina and Shiratsuka (2003) examines the impacts of the BOJ's monetary policy on the expectations of the future interest policy by analyzing the behavior of the yield curve. They find both ZIRP and quantitative easing have been effective in increasing the expected duration of zero interest rates in the future. They caution, however, that the clearly expansionary effects observed in the yield curves "failed to be transmitted outside the financial system" (p.18).

In the rest of this section, we reexamine the issue of effectiveness of monetary expansion in Japan especially under the zero short-term nominal interest rates. Our approach is similar to those employed by Kuttner and Posen (2001), Miyao (2000), and Kimura, Kobayashi, Muranaga, and Ugai (2002) in that we study the time series property of monetary aggregates (M2+CD), price (GDP deflator), and output (GDP). This paper's exercise is distinguished from the others in its focus on the long-run relation (co-integration) of the variables and on the possibility that the long-run relation may have changed over time, especially under the zero interest rates. In terms of the quantity equation, there will be such a change, for example, when the mean level of velocity shifts permanently. In this case, we may fail to find the co-integration between money, price and output for the whole sample period even when different co-integration relation exists for the period before the change and the period after the change. Thus, the failure to find the co-integration for the whole sample does not necessarily imply the absence of a long-run relation between money and output. It still may be the case that the monetary aggregate can influence the output although the magnitude of such influence changed over time.

To examine the co-integration between money and output with possible structural changes, we apply two different but complementary tests of co-integration for the system of real GDP and real M2+CD (calculated by dividing M2+CD with the GDP deflator).¹⁵ The first is the test developed by Gregory and Hansen (1996). Their tests are designed to test the null hypothesis of no co-integration against the alternative hypothesis of co-integration with a possible change in the co-integrating relation. Thus, we first apply Gregory and Hansen test to see if the variables are likely to be co-integrated, with or without regime changes. Gregory and Hansen test is designed to detect a structural change at unknown point within the middle 70% of the time series observations. In other words, the test cannot detect the regime shift if it happened in the first 15% or the last 15% of the observations.

If we find an evidence for co-integration using Gregory and Hansen test, we apply the test developed by Seo (1998) to see if there was a regime shift. Seo (1998) extended the work by Andrews (1993) and Andrews and Ploberger (1994), which developed the tests for structural changes in stationary variables, to the case of testing a change in co-

¹⁴ Their augmented Dickey-Fuller test rejects the null hypothesis that the monetary base has a unit root.

¹⁵ We adjust the GDP deflator to correct for the effects of consumption tax changes using the method described in the footnote 11.

integrating vectors. Seo's tests test the null of co-integration without regime shift against the alternative of co-integration with a regime shift. We use the version that examines the supremum LM (Sup-LM) statistic. If the null hypothesis of co-integration with no regime shifts is rejected, we identify the date when the supreme is obtained as the most likely break point. Seo (1998) plots the asymptotic critical values of the statistic for several alternative ranges of the possible structural break. In this paper, we allow the structural break to take place in the middle 90% of the observations. This is the maximum range that Seo (1998) considers. Since we are especially interested in the possibility of a structural change in the zero interest rate period, this test, which allows us to test the existence of a structural change near the end of the sample, seems reasonable to use.

Table 2 reports the results for augmented Dickey-Fuller tests for the variables we use for our analysis: GDP, GDP deflator (PGDP), M2+CD, and adjusted monetary base (M0). The last column shows the test result for real money, which is defined to be (M2+CD)/PGDP. The sample period is from the first quarter of 1980 to the fourth quarter of 2003. For all variables, we cannot reject the hypotheses that they have unit roots.

The result for Gregory Hansen test for co-integration between real GDP and real M2+CD is reported in Table 3. Because we are primarily interested in the possibility of a change in the slope of the co-integrating vector, we use the test that allows both the intercept and the slope of the co-integrating relation to change. The test rejects the null hypothesis of no co-integration, and suggests that the two series are co-integrated with possible breaks in the co-integrating vector. From this test alone, however, we cannot tell if there was a regime shift in the relation during our sample period.

To test for regime shifts, we apply Seo's test. The result is reported in Table 4. The test rejects the null hypothesis of co-integration without structural breaks, and suggests a structural break at the fourth quarter of 1995.

In Table 5, we estimate the co-integrating vector for the two sub-period (1980:I to 1995:III and 1995:IV to 2003:IV) using Johansen (1988, 1991) approach. For both sub-periods, the null hypothesis of zero co-integrating relation is rejected at 5% statistical significance but the null of only one co-integrating relation is not rejected. Thus, we can conclude that there was a stable long-run relation between real money and real GDP both before and after 1995:III.

The estimated (normalized) co-integrating vectors suggest that the co-integration was economically more significant before the break. The estimated co-integration vector suggests that a 1% increase in the (log) real money balances led to 0.62% increase in the (log) real GDP in the long run before 1995. After 1995, the estimates suggest that an increase in the real money still increases the real GDP in the long run, but the magnitude is somewhat smaller: 1% increase in real balances leads to 0.41% growth of real GDP.

Overall the examinations of long-run relation between real GDP and real M2+CD suggest a structural break in the late 1995. The timing of the structural break coincides with the reduction of the BOJ discount rate from 1.00% to 0.50% (September 1995), which started the period of extreme low interest rates. After the break, the long run relation between real GDP and real M2+CD has become weaker in the sense that the magnitude of the long-run impact of an increase in the real money on the real GDP has become smaller. Even in the period after the break, which includes the periods of ZIRP, however, the estimated long-run relation between real GDP and real M2+CD is positive, suggesting that a permanent increase in M2+CD increases the real GDP in the long run.

Although the results so far suggest a long-run relation between real M2+CD and real GDP existed even under low interest rate regime, the BOJ and many observers pointed out the difficulty of increasing the growth rate of M2+CD in the low interest rates environment, especially with ZIRP. Even if the BOJ massively increase the monetary base, the argument went, it does not add to M2 because the banks cannot find worthy borrowers and just hoard the new money in the form of reserves. Kuttner and Posen (2001) and Hutchison (2004) also find the M2 multiplier (M2 divided by monetary base) declined substantially over the 1990s.

Tables 6 through 10 examine the long-run relation between M2+CD and the monetary base.¹⁶ Table 6 reports the result of the Gregory and Hansen test. The result suggests that the null of no co-integration cannot be rejected. The result of Seo's test reported in Table 7 suggests that the null of co-integration without structural breaks cannot be rejected either. Two results are inconsistent because if the two series are not co-integrated as the Gregory and Hansen test suggests, Seo's test should detect that and reject the null of co-integration (without breaks). Thus, the results from Tables 6 and 7 are inconclusive on the long-run relation between M2+CD and the monetary base.

For M2+CD and the monetary base, the data are available at higher frequencies than quarterly. To check the possibility that the use of quarterly data in Tables 6 and 7 reduced the power of these tests, we apply the same tests using monthly data. We also extended the sample period to start in 1970.¹⁷ The results are reported in Tables 8 and 9. Again Gregory and Hansen test fails to reject the null of no co-integration (Table 8). Seo's test, however, rejects the null of co-integration without a structural change and suggests a break at October 1998. Strictly speaking, we again have an inconclusive result, because October 1998 is within the middle 70% range of the sample, where we allow Gregory and Hansen test to detect the break. This observation, however, is almost at the very end of the range, and the power of Gregory and Hansen test is known to decline as the break point approaches the boundary of the range. If we discount the result of Gregory and Hansen test on this ground and focus on the Seo's test, we can conclude that

¹⁶ Both series are seasonally adjusted. We further adjust the adjusted monetary base to remove the effects in December 1999 and January 2000. To do this, we first estimate an ARMA model of the (monthly) M0 with dummy variables for December 1999 and January 2000. We estimate the M0 for those observations in the absence of Y2K effects using the estimates when the dummies are set to zero. The quarterly data for M0 are obtained by averaging the monthly data for each quarter.

¹⁷ We could just extend the sample period without increasing the frequency of the data. In this case, however, the result is qualitatively the same with the result for quarterly data from 1980:1 to 2003:IV.

the result from monthly data suggests a co-integrating relation between M2+CD and the monetary base with a structural break at October 1998. The examination of quarterly data failed to detect this probably because of the lack of the power.

We proceed and test for co-integration for two sub-periods suggested by the result of Seo's test. Table 10 shows the result. The Johansen (1988, 1991) test of co-integration rejects the null of no co-integration for both sub-periods. Thus, we find a co-integrating relation between M2+CD and the monetary base in each sub-periods. The examination of the estimates of co-integrating vectors for the two periods suggests that the size of monetary base that corresponds to a certain level of M2+CD increased over time. Before October 1998, to increase M2+CD by 1%, the BOJ needed to increase the monetary base by 0.23%. After October 1998, the BOJ needed to raise the monetary base by 1.99% to increase M2+CD by 1%.

The finding here is overall consistent with the finding by Hutchison (2004) on the change in the money multiplier over time. Using the recursive residual test, he finds a structural break in money multiplier in late 1997. We also find a similar structural break in the long-run equilibrium money multiplier.

Both our result and Hutchison (2004) suggest that the relation between M2+CD and the monetary base has become weaker in the late 1990s. The positive relation between monetary base and M2+CD, however, still existed even after the structural break. Thus, it was still possible to increase M2+CD by expanding the monetary base. It just took a larger amount of monetary base now to increase M2+CD by a certain proportion.

5. Conclusion

This paper has reviewed the conduct of monetary policy in Japan during the "great recession." The paper has paid a special attention to the period when the ZIRP (zero interest rate policy) was in place. The nominal call rate reached as close as zero it can get under the ZIRP. The real call rate, however, stayed above zero because of deflation. Growth rates of monetary aggregates under the ZIRP were not particularly high until the BOJ expanded their efforts of "quantitative easing" in late 2002.

Our empirical analysis shows there was a long-run relation between the real M2+CD and the real GDP throughout our sample period (1980-2003), although the slope of the co-integrating vector changed around late 1995. Thus, monetary policy did not lose its long-run effectiveness in this sense. The central bank, however, cannot directly control M2+CD. The co-integrating relation between M2+CD and the monetary base is less clear-cut when we use the quarterly data. Using monthly data, however, we find a co-integrating relation between M2+CD and the monetary base with a structural break around October 1998. In both before and after the regime shift, the long-run relation between M2+CD and the monetary base is positive, suggesting an increase in the monetary base leads to an increase in M2+CD in the long run. Overtime, the relation has become weaker in the sense that it takes a larger increase in the monetary base to

generate a reasonable growth in M2+CD. Even after the regime change, however, the relation between M2+CD and the monetary base has been still positive, suggesting an increase in the monetary base still leads to an increase in M2+CD. Thus, our results suggest that a massive quantitative easing increases M2+CD, and eventually increase the output as well.

Our results do not refute the BOJ's view that the Japanese economic problems are mostly structural and there is little monetary policy can do. Indeed, the structural break that we find in the long-run relation between the monetary base and M2+CD is consistent with the view that the structural problem substantially weakened an important part of the monetary transmission mechanism. As Hutchison (2004) and others argue, the reduction of money multiplier may have been caused by the problems in the Japanese financial system.¹⁸ We stress the finding, however, that the long-run relation between the monetary base and M2+CD has been still positive even after the structural break in the late 1990s. Thus, the monetary policy could have been more expansionary.

Since the late 2002, the BOJ has been increasing the monetary base. Consistent with our result, M2+CD also has been increasing albeit slowly. Mr. Fukui has been stressing that the quantitative easing will not be terminated until Japan is not likely to fall back into deflation. The economy also started to recover in late 2003. Whether the recovery will finally pull Japan out of the Great Recession and how much credit monetary policy can claim for the recovery remain to be seen at this writing (July 2004), but the premature tightening similar to the one in August 2000 is highly unlikely.

¹⁸ See Hoshi and Kashyap (2004) for more on the problems of the Japanese financial system.

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Table 1. Major Changes in the Monetary Policy Stance of the BOJ: 1998-2003

Apr. 1, 1998	<ul style="list-style-type: none"> • BOJ gained independence • Masaru Hayami becomes the 28th BOJ Governor • Continue to encourage the uncollateralized overnight call rate to remain on average slightly below the official discount rate (0.50%)
Sept. 9, 1998	<ul style="list-style-type: none"> • Encourage the uncollateralized overnight call rate to move on average around 0.25%
Feb. 12, 1999	<ul style="list-style-type: none"> • Encourage the uncollateralized overnight call rate to move as low as possible (start of the ZIRP)
Aug. 11, 2000	<ul style="list-style-type: none"> • Encourage the uncollateralized overnight call rate to move on average around 0.25%
Feb. 9, 2001	<ul style="list-style-type: none"> • Reduce the official discount rate by 15 basis points to 0.35% • Introduce a standby lending facility at the official discount rate ('Lombard-type' lending facility) • Increase outright operations of short-term government securities
Feb. 28, 2001	<ul style="list-style-type: none"> • Encourage the uncollateralized overnight call rate to move on average around 0.15% • Reduce the official discount rate to 0.25%
Mar. 19, 2001	<ul style="list-style-type: none"> • Change the main operating target from the uncollateralized overnight call rate to the outstanding balance of the current accounts at the BOJ • The new procedure continue to be in place until the consumer price index (excluding perishables, on a nationwide statistics) registers stably a zero percent or an increase year on year • Target the current-account balance at the BOJ to be around ¥5 trillion • Expect the uncollateralized overnight call rate to be close to zero
Aug. 14, 2001	<ul style="list-style-type: none"> • Raise the target balance of current accounts held at the BOJ to ¥6 trillion • Increase outright purchase of long-term government bonds to ¥600 billion per month
Sept. 18, 2001	<ul style="list-style-type: none"> • For the time being, provide ample liquidity to the money market by aiming at maintaining the outstanding balance of current accounts held at the BOJ above ¥6 trillion • Reduce the official discount rate by 15 basis points to 0.10% • Increase the maximum number of business days for using the Lombard-type lending facility (from 5 days to 10 days)
Dec. 19, 2001	<ul style="list-style-type: none"> • Raise the target outstanding balance of the current accounts at the BOJ to around ¥10 trillion to ¥15 trillion • Increase outright purchase of long-term government bonds to ¥800 billion per month
Feb. 28, 2002	<ul style="list-style-type: none"> • For the time being, provide more liquidity to meet a surge in demand irrespective of the target of current account balances • Increase outright purchase of long-term government bonds to ¥1 trillion per month

Table 1 (Continued)

Sept. 18, 2002	<ul style="list-style-type: none">• Announce the plan to purchase stocks from banks
Oct. 11, 2002	<ul style="list-style-type: none">• Set the limit of stock purchase from banks at ¥2 trillion by the end of September 2004
Oct. 30, 2002	<ul style="list-style-type: none">• Raise the target outstanding balance of the current accounts at the BOJ to around ¥15 trillion to ¥20 trillion• Increase outright purchase of long-term government bonds to ¥1.2 trillion per month
Mar 20, 2003	<ul style="list-style-type: none">• Toshihiko Fukui becomes the 29th BOJ Governor
Mar. 25, 2003	<ul style="list-style-type: none">• From April 1, raise the target range to ¥17 trillion to ¥22 trillion (due to the establishment of the Japan Post)• For the time being, provide more liquidity irrespective of the target when necessary to secure financial market stability• Raise the limit of stock purchase to ¥3 trillion by the end of September 2004
Apr. 30, 2003	<ul style="list-style-type: none">• Raise the target outstanding balance of the current accounts at the BOJ to around ¥22 trillion to ¥27 trillion• For the time being, provide more liquidity irrespective of the target when necessary to secure financial market stability
May 20, 2003	<ul style="list-style-type: none">• Raise the target outstanding balance of the current accounts at the BOJ to around ¥27 trillion to ¥30 trillion• For the time being, provide more liquidity irrespective of the target when necessary to secure financial market stability
Oct. 10, 2003	<ul style="list-style-type: none">• Raise the upper bound for the target range for the outstanding balance of the current accounts at the BOJ to ¥32 trillion• Clarify the commitment to maintain the quantitative easing. To terminate the quantitative easing, it is necessary (i) for the core CPI inflation of 0% or above to continue for a few months, and (ii) for the BOJ to be convinced the core CPI inflation will not be expected to register 0% or below in the near future.
Jan. 20, 2004	<ul style="list-style-type: none">• Raise the target outstanding balance of the current accounts at the BOJ to around ¥30 trillion to ¥35 trillion

Source: Bank of Japan web site “Monetary Policy” section (http://www.boj.or.jp/en/seisaku/04/seisak_f.htm).

Table 2. Phillips-Perron Test for Unit Root

	GDP	GDP Deflator	M2+CD	Monetary Base	Real Money
Z(t) statistic	-0.5025	-2.6756	-0.6632	-0.8167	-1.6703

Notes: Sample period is from 1980:I to 2003:IV. Real Money is calculated by dividing M2+CD by the GDP Deflator. The tests allow both drift and trend in the process. The null hypothesis is presence of a unit root in the univariate process. The critical values of Z(t) statistics are -4.0570 (1% level), -3.4571 (5% level), and -3.1542 (10% level).

Table 3. Gregory and Hansen Test for Co-integration: Real GDP and Real M2+CD

Sample period	1980:I to 2003:IV
Z(t) statistic	-6.7403

Notes: The null hypothesis is absence of co-integration. The critical value at 5% level is -4.95.

Table 4. Seo Test for Structural Change: Real GDP and Real M2+CD

Sample period	1980:I to 2003:IV
Sup-LM	12.17
Most likely break point	1995:IV
Number of lags	2

Notes: The lag length for each system was chosen to minimize Schwartz's criterion. The null hypothesis is co-integration without structural breaks. The critical value for Sup-LM at 5% level is 10.04. The test tests for a structural change in the middle 90% range of the sample.

Table 5. Test for Co-integration in Sub-periods: Real GDP and Real M2+CD

Sample period	1980:I to 1995:III	1995:IV to 2003:IV
H ₀ : no co-integration	27.7035	22.6419
H ₀ : at most one co-integration	8.6024	8.4459
Normalized co-integrating vector (GDP, M2+CD)	(1, -0.6220)	(1, -0.4139)
Number of lags	4	4

Notes: The lag length for the system was chosen to minimize Schwartz's criterion. The first test tests the null of no co-integration against the alternative of at least one co-integration. The critical value for the test statistic is 19.96 (5% level). The second test tests the null of at most one co-integration against the alternative of at least two co-integrations. The critical value for the test statistic is 9.24 (5% level) in this case. The critical values are taken from the tables in Osterwald-Lenum (1992).

Table 6. Gregory and Hansen Test for Co-integration: M2+CD and Monetary Base (Quarterly data)

Sample period	1980:I to 2003:IV
Z(t) statistic	-2.6016

Notes: The null hypothesis is absence of co-integration. The critical value at 5% level is -4.95.

Table 7. Seo Test for Structural Change: M2+CD and Monetary Base (Quarterly data)

Sample period	1980:I to 2003:IV
Sup-LM	2.9773
Most likely break point	NA
Number of lags	2

Notes: The lag length for each system was chosen to minimize Schwartz's criterion. The null hypothesis is co-integration without structural breaks. The critical value for Sup-LM at 5% level is 10.04. The test tests for a structural change in the middle 90% range of the sample.

Table 8. Gregory and Hansen Test for Co-integration: M2+CD and Monetary Base (Monthly Data)

Sample period	1970:01 to 2003:12
Z(t) statistic	-2.1354

Notes: The null hypothesis is absence of co-integration. The critical value at 5% level is -4.95.

Table 9. Seo Test for Structural Change: M2+CD and Monetary Base (Monthly Data)

Sample period	1970:01 to 2003:12
Sup-LM	44.0295
Most likely break point	1998:10
Number of lags	2

Notes: The lag length for each system was chosen to minimize Schwartz's criterion. The null hypothesis is co-integration without structural breaks. The critical value for Sup-LM at 5% level is 10.04. The test tests for a structural change in the middle 90% range of the sample.

Table 10. Test for Co-integration in Sub-periods: M2+CD and Monetary Base (Monthly Data)

Sample period	1970:01 to 1998:09	1998:10 to 2003:12
H ₀ : no co-integration	53.2856	33.5735
H ₀ : at most one co-integration	7.9763	9.0980
Normalized co-integrating vector (M2+CD, Monetary Base)	(1, -4.4150)	(1, -0.5034)
Number of lags	4	2

Notes: The lag length for the system was chosen to minimize Schwartz's criterion. The first test tests the null of no co-integration against the alternative of at least one co-integration. The critical value for the test statistic is 19.96 (5% level). The second test tests the null of at most one co-integration against the alternative of at least two co-integrations. The critical value for the test statistic is 9.24 (5% level) in this case. The critical values are taken from the tables in Osterwald-Lenum (1992).

Figure 1. Overnight Call Rate (Collateralized): 1974:01 – 2003:12

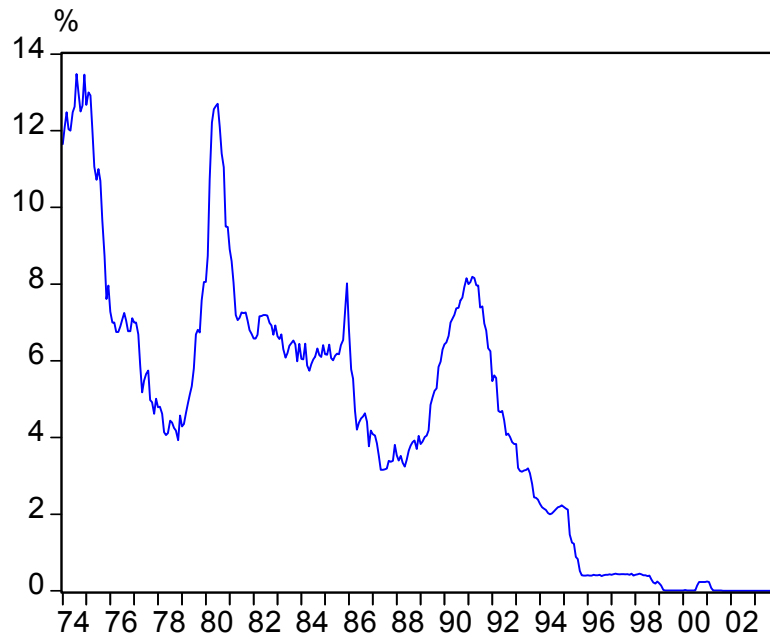


Figure 2. Real Call Rate (Call rate minus CPI inflation rate): 1974:01 – 2003:12

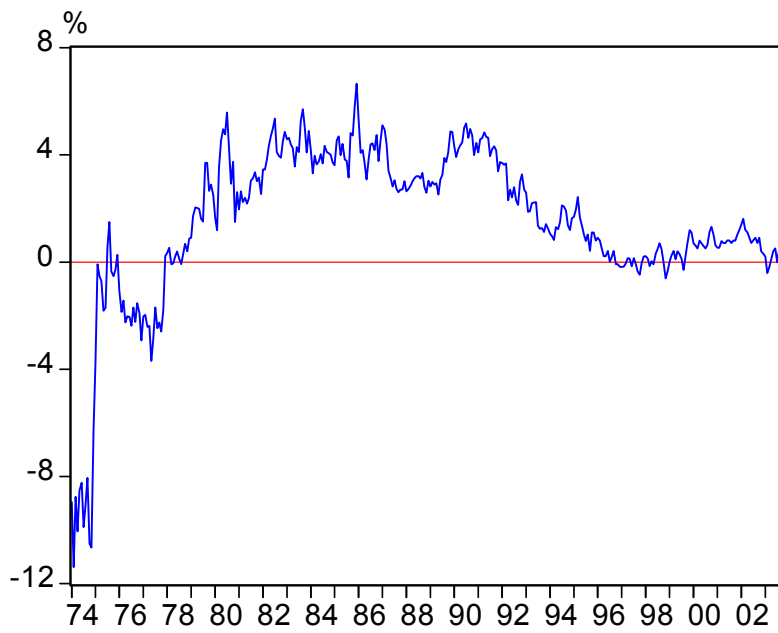


Figure 3. Growth Rate of M2+CD (year on year): 1974:01 – 2003:12

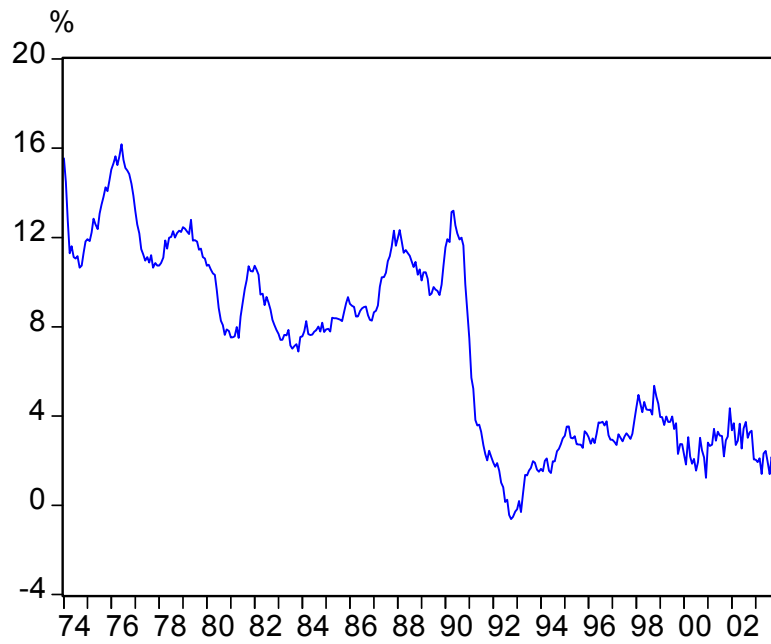


Figure 4. Growth Rate of Adjusted Monetary Base (year on year): 1974:01 – 2003:12

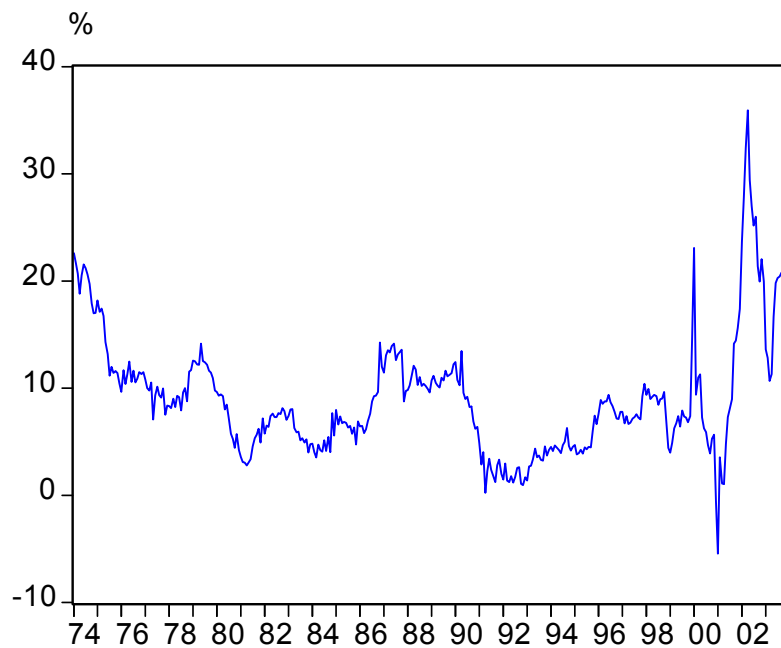


Figure 5. Growth Rate of M2+CD minus CPI Inflation Rate: 1974:01 – 2003:12

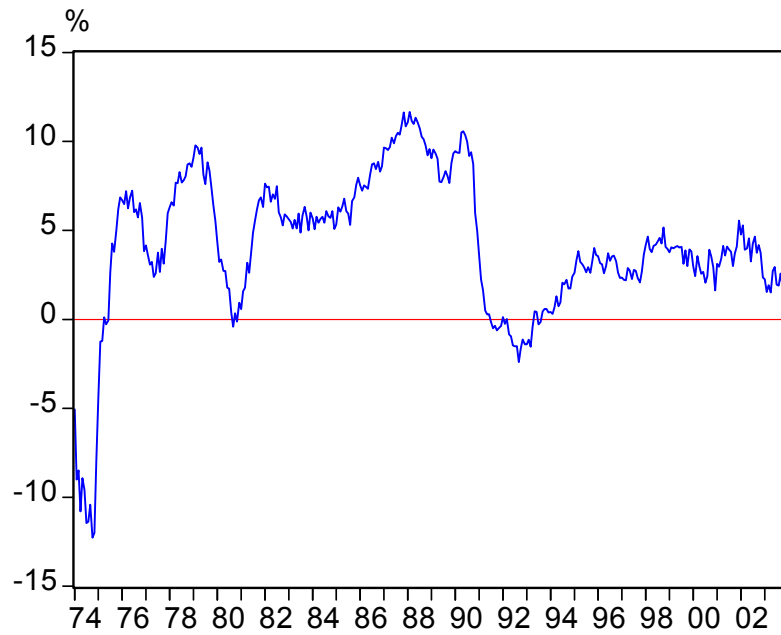


Figure 6. Growth Rate of Adjusted Monetary Base minus CPI Inflation Rate: 1974:01 – 2003:12

